



The Effect of Repeated Liquid Swine Manure Applications on Soil Nutrient Supply Rates and Growth of Different Hybrid Poplar Clones



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INTRODUCTION

- Intensive hog operations generate large amounts of manure that must be dealt with in an environmentally responsible and economically practical manner.
- Given that fast-growing trees, such as hybrid poplar, have high soil moisture and nutrient demands, they represent a tremendous sink for the applied effluent and, therefore, repeated applications of liquid swine manure within nearby hybrid poplar plantations may be an effective alternative manure management practice.

OBJECTIVES

- Evaluate the effect of repeated broadcast applications of liquid swine manure on soil nutrient supply rates and growth of different juvenile hybrid poplar clones.
- Assess the relationship between growing season soil nutrient supply rates, measured using *in situ* burials of ion-exchange membrane (Plant Root Simulator (PRS)TM-probes; Figure 1), and growth of different hybrid poplar clones.

MATERIALS & METHODS

- The data for this study were collected over two growing seasons and the experiment was a randomized complete block design, consisting of annual broadcast applications of liquid swine manure (approximately 14,000 L/ha) and five hybrid poplar clones (CanAm, Hill, Katepwa, Walker, and WT-66V), replicated three times.
- PRSTM-probes were used to measure soil nutrient dynamics *in situ* and were left in soil for five weeks and then replaced with fresh PRSTM-probes twice more during each growing season.



Anion-exchange PRSTM-probe: quaternary ammonium (R-NH₄⁺)
adsorbs: NO₃⁻, PO₄⁻, SO₄⁻, micros, etc.

Cation-exchange PRSTM-probe: sulfonic acid (R-SO₃⁻)
adsorbs: NH₄⁺, K⁺, Ca²⁺, Mg²⁺, etc.

Figure 1. Plant Root SimulatorTM -probes used to measure the effects of broadcasted liquid swine manure on soil nutrient availability (Photo courtesy of Dr. Ken Van Rees).

RESULTS

Soil nutrient bioavailability with and without manure amendment

Table 1. Mean (n=3) cumulative nutrient supply rates (µg/10cm²/15 weeks), measured using *in situ* burials of PRSTM-probes, in plots with and without liquid swine manure application.

Treatment	Year 1										
	NH ₄ ⁺	NO ₃ ⁻	Total N	P	K	S	Ca	Mg	Mn	Fe	
With Manure [†]	8a ^{††}	1369a	1378a	3.4a	65a	141a	4164a	1090a	13.0a	52.8a	
Without Manure	6a	633b	639b	2.5a	65a	112a	4143a	955a	3.8a	25.2a	
Year 2											
With Manure	15a	1597a	1612a	42.0a	119a	208a	7084a	1518a	60.4a	164.8a	
Without Manure	9a	147b	157b	9.7b	52a	227a	6426a	1375a	6.2b	45.1b	

[†] Approximately 14,000 L/ha broadcast applied on June 25, 2004 and July 19, 2005.

^{††} For each year, means within a column followed by the same letter are not significantly different (P > 0.05) by LSD.

Soil nitrogen dynamics with and without manure amendment

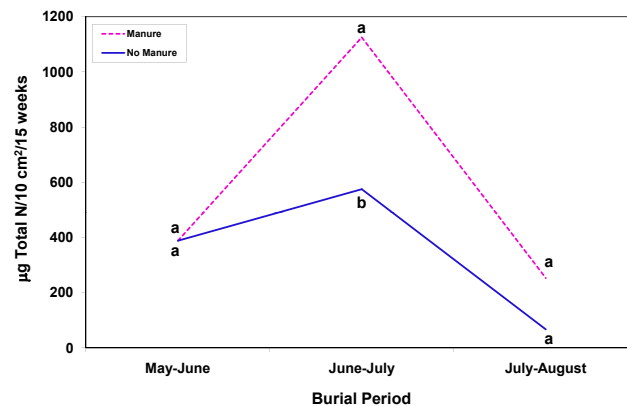


Figure 2. Mean (n=3) total N supply rates, measured using *in situ* burials of PRSTM-probes, in plots with and without a broadcast application of liquid hog manure on June 25, 2004 at a rate of approximately 14,000 L/ha. For each burial period, means having the same letter are not significantly different (P > 0.05) using LSD.

Hybrid poplar growth with and without manure amendment

Table 2. Mean (n=3) height, diameter at breast height, and stem volume growth increments for hybrid poplar after 2005 season, in plots with and without applied liquid swine manure.

Treatment	Height (cm/year)				
	CanAm	Hill	Katepwa	Walker	WT-66V
With Manure [†]	92.1a ^{††}	96.8a	113.3a	117.2a	89.3a
Without Manure	125.4a	86.8a	100.9a	119.7a	88.2a
Diameter at Breast Height (cm/year)					
With Manure	1.1a	1.3a	1.5a	1.5a	1.1a
Without Manure	1.3a	1.3a	1.3a	1.5a	1.2a
Stem Volume (cm ³ /year)					
With Manure	351.1a	489.8a	685.5a	588.8a	304.6a
Without Manure	380.2a	500.4a	568.0b	576.8a	290.2a

[†] Approximately 14,000 L/ha broadcast applied on June 25, 2004 and July 19, 2005.

^{††} For each growth parameter, means within a column followed by the same letter are not significantly different (P > 0.05) by LSD.

Relationship between PRSTM-probe data and hybrid poplar growth

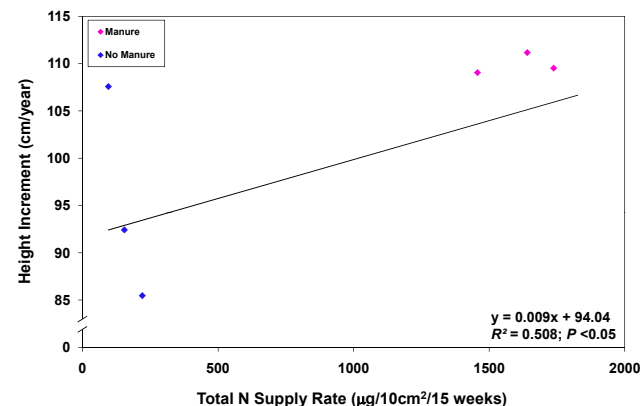


Figure 3. Relationship between total N supply rate, measured using *in situ* burials of PRSTM-probes, and 2005 height growth increment of five hybrid poplar clones (CanAm, Hill, Katepwa, Walker, and WT-66V). Each data point is a mean of 50 four-year-old trees, in plots with and without broadcast applied liquid swine manure (14,000 L/ha) on June 25, 2004 and July 19, 2005.

DISCUSSION & CONCLUSIONS

- The limited effect of hog effluent on soil nutrient supply rates after the first year and hybrid poplar growth after two years is surprising considering the application rate was 3x larger than the agronomic rate, and may be attributable to: i) substantial volatilization losses due to broadcast application (Hoff et al., 1981)¹, ii) microbial immobilization given the large amount of soluble carbon in manure (Thomsen et al., 1997²; Wen et al., 2003³), iii) increased leaching and denitrification losses, caused by above-average rainfall supporting prolonged saturated conditions, iv) timing of manure application being out of sync with temporal nature of nutrient uptake by the trees (i.e., applied after the period of maximum nutrient uptake), therefore, resulting in low manure use efficiency, and v) a delayed response as absorbed nutrients are retranslocated within the tree tissues to support increased growth in subsequent years (Hawkins et al., 1998⁴; Salifu and Timmer, 2003⁵).
- Determining the effects of repeated applications of liquid swine manure on soil nutrient supply rates and subsequent tree growth should help to support effective management strategies, in terms of developing practical effluent management practices required to mitigate any adverse environmental effects, but also increasing plantation productivity and the concomitant non-wood product benefit of increasing biodiversity within the agricultural landscape.
- The strong correlation existing between the PRSTM-probe soil nutrient supply measurements and early growth of different hybrid poplar clones, demonstrate the utility of the PRSTM-probe in assessing soil nutrient dynamics within hybrid poplar plantations.

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